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Final Report

Processing of older submarine ice draft data

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LONG-TERM GOALS

Arctic sea ice thickness is critical to geophysical research into climate change, shipping, biological productivity and other things. The overall goal of this work is to produce a public archive of ice draft data for research. The data is meant to span the largest time range possible and be of the highest possible quality. In addition the data must include detailed and accurate documentation.

OBJECTIVES

This work is meant to (1) produce publicly released ice draft data from 1959 to 1975 as taken by US Navy submarines, (2) produce recent data from after 2011.

APPROACH

Software will be adapted for processing of older data. Software will also be developed to process the newest available data. Both older and newer data will be processed, declassified and added to a public archive at NSIDC. A regression analysis will be performed on existing data in the archive to determine the impact of boat speed and depth on data quality. A report will be written on this work for inclusion in the public archive. All of the work will be completed by Dr. Mark Wensnahan.

WORK COMPLETED

Work in 2013 under this grant consisted of 4 basic tasks: (a) a regression analysis of the effect of ship depth and speed on mean draft and other statistics, (b) development of software to process both digital and analog data, (c) processing and analysis of data from two cruises in 2011 and (d) beginning processing of older analog data.

Software Development

Software was needed to process a number of cruises worth of digitally recorded data. It was necessary to build the software from scratch as no existing software was available. The software displays data, allows the user to define calibration points, and allows the user to mark data for exclusion from the final product. With this input it produces an edited and calibrated product suitable for inclusion in the NSIDC archive.

Software existed to process certain kinds of analog strip chart data. It was necessary to modify the existing software to allow processing of several other types of charts. Modifications included (a) ability to process rectilinear chart data rather than curvilinear, (b) determination of chart wander in the scanned image, (c) inversion of scanned images and (d) contrast and brightness adjustment of scanned images. This was a particularly time-consuming task given the complex nature of the software.

Processing of 2011 data

Data from two cruises during 2011 were obtained from the US Navy Arctic Submarine Lab in San Diego. Initially the data were thought to be unusable but detailed study showed that the data could in fact be processed using software developed in the previous task. The draft data were compiled from

spreadsheets while navigation data were compiled from a few different sources. Navigation and draft data were then merged and processed. One cruise had fairly high quality data that was straightforward to process. The other cruise had noisy data requiring a significant amount of editing. Ultimately several thousand kilometers of draft data were produced for two important routes through the Arctic. The data have been submitted to the NSIDC archive. The addition of these data to the archive were advertised as part of a presentation at the Fall American Geophysical Union conference in San Francisco. The presentation compared the 2011 data with previous submarine data, model output, and ice thickness products from the CRYOSAT-2 radar altimeter. Unfortunately, only after AGU was it revealed that the data from 2011 were taken in a manner not consistent with previously released data. Instead of being first return, the 2011 data are peak return meaning the ice thickness is measured not from the deepest ice but from that part of the ice with the strongest signal. There is some possibility of correcting these data to the equivalent of first return.

Processing of Analog Data

There are fifteen cruises from 1958 to 1970 for which there are analog data. All of these cruises were reviewed for possible processing. Of these 6 were rejected because the data were of poor quality. A further 3 were rejected since none of the data are withing the data release area (that area outside to the economic zones of foreign nations and thus available for declassification). Two were rejected as being incomapatible with the rest of the data in the archive as it was taken using a widebeam sonar system rather than the narrow beam system of the other data. This left 4 cruises which were processed for declassification.

Processing was delayed by the extensive revision required for the exiting processing software as detailed above. Modifications were made to process the final 4 cruises but also for a number of cruises which were ultimately deemed beyond salvaging. Processing involves a sequence of complex and painstaking steps to calibrate and edit the data then merge the data with navigation metadata. With each cruise processed, lessons were learned that allowed improvements to be made to the already-processed cruises. For the four cruises done, the data were sent to the Navy Arctic Submarine Lab for declassification some months ago. Unfortunately, the data were misplaced at ASL due to a clerical error and are only just now being declassified. The data have been submitted to the National Snow and Ice Data Center for public archiving.

RESULTS

Processing of draft data requires sophisticated image processing software. By developing software to process ice draft data we now have the capability to produce data that significantly increases the time span covered by the draft data. The current archive covers 26 years from 1975 to 2005. With new software we have have extended that record from 1960 to 2011 or a span of 51 years.

IMPACT/APPLICATIONS

Ice thickness data is used for a large variety of research. An obvious example is climate change. Here the length of record is crucial to establish the past climate and how the climate has changed over the last 50 years. At the same time modern data is regularly used to initialise climate models and improve their predictive power. The data is also often used to validate other methods of determining ice thickness, particularly satellite-based measurements.

RECOMMENDATIONS FOR FUTURE WORK

It is imperative that the record of ice thickness be continued into the future. There are two potential prongs to this effort. First, the development of an ice draft data recorder would make it possible to record the ice draft data independent of whatever equipment the US Navy has aboard submarines already for this purpose. At the same time the Navy is developing and deploying a new data recorder that may provide high quality data in the future. One or preferably both of these technologies should be pursued in the near term until it is clear that one or theother provides consistently high quality data.

RELATED PROJECTS

ONR Contract, Arctic Ice-Cap Submarine Top Sounder Recording, N00014 13 C 0208

PUBLICATIONS

Wensnahan, 2013, "Submarine-based Sea-ice Draft measurements from 2011 ICEX", 2013 AGU Fall Meeting, 9-13 December 2013

Wensnahan, 2013. “Assessing the impact of speed and depth on sea-ice draft data obtained from US Navy submarines.” Technical report, National Snow and Ice Data Center.

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14. ABSTRACT
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Processing of draft data requires sophisticated image processing software. By developing software to process ice draft data we now have the capability to produce data that significantly increases the time span covered by the draft data. The current archive covers 26 years from 1975 to 2005. With new software we have have extended that record from 1960 to 2011 or a span of 51 years.

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